Final
Kaneohe Stream
Bioassessment

Susan Burr presently with AECOS, Inc.
January 2003
Prepared for the Hawaii State Department of Health

Acknowledgements
The author wishes to thank Ric Guinther (AECOS) and Paul Chong (DOH/CWB) and also June Harrigan, Melissa Farinas O'Connor and David Penn (DOH/EPO) for assisting with the fieldwork. Ric Guinther provided many of the photographs.

Biological Assessment of Hawaiian Streams

Why Assess Streams?

The goal of the 1972 Federal Clean Water Act is to achieve "fishable and swimmable" waters for all Americans by restoring and maintaining the chemical, physical, and biological integrity of the Nation's surface waters (33 U.S.C. §1251). The Hawaii State Water Code (Hawaii Revised Statutes (HRS), Chapter 342D) states that the waters of the State are held for the benefit of citizens who have a right to have the waters protected for their use. In an effort to meet these national and state goals, the Hawaii State Department of Health has promulgated regulations (Hawaii Administrative Rules (HAR) Chapter 11-54, Water Quality Standards) that designate uses, set water quality criteria, and establish an antidegradation requirement for all State waters.

Biennially, the Hawaii Department of Health (HIDOH) compiles a list of surface waters that do not comply with the State water quality standards – known as the Clean Water Act §303(d) List of Water Quality-Limited Segments, or List. The State is then required to determine the Total Maximum Daily Load (TMDL) of pollutants for the water bodies that are on the List. The waters of Kaneohe Bay that surround the mouth of Kaneohe Stream (see Figure 1) along with other stations within Kaneohe Bay were included in Hawaii's 2002 List because they showed evidence that excess nutrients and sediments impaired them. Because it is difficult to calculate TMDLs for coastal waters and it is believed that streams carry many of the pollutants into the bay, the Department of Health is examining the chemical, physical, and biological integrity of the streams first and will calculate TMDLs for the streams instead of the bay. Reduction of the pollutant load to the streams to TMDL levels should result in improved water quality in the bay and ultimately its removal from the list of impaired water bodies. If the water quality in the bay continues to exceed water quality standards following the establishment and implementation of TMDLs for the streams, then TMDLs will be established for Kaneohe Bay itself. This bioassessment of Kaneohe Stream will be used in coordination with chemical and physical measurements to determine the maximum pollutant load of nutrients and sediments that Kaneohe Stream can accept and still meet water quality standards.

Hawaii Stream Bioassessment Protocol

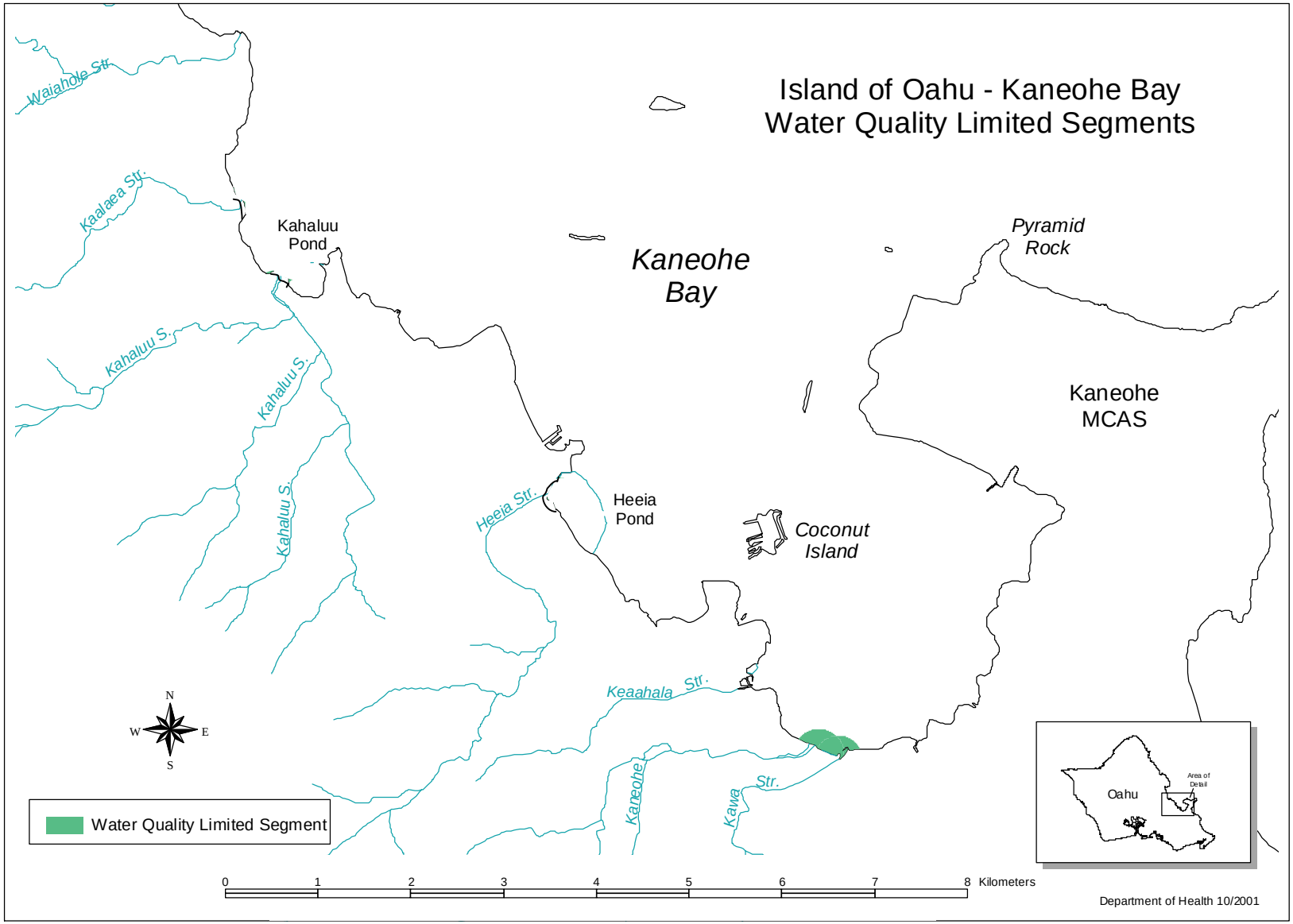
The US Environmental Protection Agency (EPA) promotes the use of rapid bioassessment protocols as screening tools to determine if streams support designated aquatic life uses, to characterize the location and severity of use impairment, and to help identify causes of use impairment. Rapid bioassessment protocols compare habitat characteristics and biological metrics with reference conditions (Plafkin et al., 1989).

Hawaii's Department of Health is considering revising Hawaii's Water Quality Standards to include habitat and biotic integrity scores as criteria for Class 1a and Class 2a perennial streams (HIDOH, 2001). The habitat and biotic integrity scores would complement existing physical and chemical criteria in the Water Quality Standards, but would be used primarily to evaluate streams proposed to be reclassified and to prepare TMDLs. The Department of Health would also like to ultimately collect enough data to correlate habitat and biotic integrity scores with compliance to physical and chemical criteria – such that the US Environmental Protection Agency can accept and approve TMDLs related to habitat and biotic integrity.

Most Hawaiian streams are short and steep and have low but flashy flows. Uniquely adapted native animals have evolved in these conditions – some even have the ability to climb waterfalls. These species depend upon heavy rains for reproductive success, and all exhibit an amphidromous lifecycle where fish lay eggs in freshwater, larvae are carried downstream and drift in oceanic plankton, and juveniles return to streams (Kinzie, 1990). Native aquatic

.

Figure 1. Kaneohe Bay Water Quality Limited Segments.



macrofaunal species are used as biological indicators of stream quality in Hawaii because they are known to be sensitive to environmental degradation, taxonomically unique, readily identifiable, specifically adapted to Hawaiian stream environments, and found on all islands (Kido et al., 1999). Various habitat characteristics are also evaluated to assess the conditions of the environment in terms of the support it provides for the native species.

Metric scores were developed on an ecoregional scale (all main Hawaiian islands), using a data set that includes sites that range in condition from least impaired to highly degraded. State reference conditions are the set of highest index scores (100%) computed in the State. The key to interpreting scores assigned to sites using the bioassessment protocol is to compare them to reference conditions (Table 1).

Table 1. ***Guideline values for interpreting attainment of aquatic life uses in Hawaiian streams.***

Habitat	Biological
(% of reference)	
<50% = nonsupporting	<30% = impaired
50-75% = partially supporting	30-70% = moderately impaired
75% = supporting	70% = unimpaired

When assessed together, the habitat characteristics and biological metrics indicate the degree of impairment of a stream and, when evaluated with various physical and chemical parameters, can be used to determine TMDLs for the stream. Once TMDLs have been estimated, implementation measures will be developed to restore the chemical, physical, and biological integrity of the stream, in line with Clean Water Act goals.

Kaneohe Stream

Kaneohe Stream is the third stream in Hawaii for which the Department of Health has conducted a bioassessment as part of a TMDL study. The Department of Health conducted the first two bioassessments on two other windward Oahu streams – Waimanalo Stream (Smith, 1998) and Kawa Stream (Burr, 2001). Each assessment follows the Hawaii Stream Bioassessment Protocol (HSBP), with the use of electrofishing techniques instead of the Underwater Visual Census, primarily because the water is too shallow in these streams to snorkel (Kido et al., 1999) (Figure 2). The Department of Health's policy with respect to electrofishing is to utilize electrofishing when waters are (1) thought to be polluted to a point that poses a risk to human health, (2) too turbid to examine fish adequately underwater, (3) overrun with small introduced fish that are difficult to count underwater or (4) not deep enough to snorkel (K. Henderson, DOH, pers. comm.).

Figure 2. ***Electrofishing in Kaneohe Stream.***

.

Several tributaries originate in the Koolau mountains and eventually lead to what is called Kaneohe Stream as it flows through the approximately 14.7 square kilometers watershed (Figure 3). The lower half of the watershed is zoned as urban land, and the entire upper half is zoned for conservation, although a variety of land uses exist throughout the watershed. The Pali Golf Course, Koolau Golf Course, a banana plantation, the Hoomaluhia Botanical Gardens, and part of the Kaneohe Forest Reserve are situated in the conservation district of Kaneohe Watershed. Parts of three major highways that lead to the other side of the island, the Pali Highway, H-3 Freeway, and the Likelike Highway, bisect the conservation district. Most of the tributaries to Kamooalii tributary flow through Hoomaluhia Reservoir before entering the urban district. The urban district of the watershed consists of primarily residential and commercial buildings and numerous paved roads. Much of the stream is channelized or hardened in the urban district before it flows into Kaneohe Bay, next to Kaneohe Beach Park.

Small sections of the headwaters of some of the tributaries to Kaneohe Stream originate in the Protective Subzones of the Conservation District and are therefore classified as Class 1 Perennial Streams in Hawaii's Water Quality Standards (Figure 4). According to the Water Quality Standards, these waters are to remain in their natural state with an absolute minimum of pollution from any human-caused source. The most sensitive use to be protected in these reaches is protection of native breeding stock. TMDL implementation goals for habitat and biotic integrity, based upon the Water Quality Standards, are established for these Class 1 segments in this report; however we do not know the extent to which these goals are currently being met because we did not survey these segments due to their inaccessibility.

The remaining segments of Kaneohe Stream are classified as Class 2 Perennial Streams. The relevant uses to be protected in the Class 2 segments include recreation, the support and propagation of aquatic life, and agricultural supplies. TMDL implementation goals for habitat and biotic integrity are established for these segments and the surveys indicate the extent to which these goals are currently being met.

Assessment of Biological Integrity of Kaneohe Stream

Methods

Personnel from HIDOH and its TMDL contractor, *AECOS*, Inc., selected three sites on Kaneohe Stream to conduct the bioassessments – Kamoo Bridge, Kamooalii Tributary, and Koolau Golf Course (see Figure 3). Each assessment site roughly corresponds to a HIDOH Clean Water Branch water quality sampling location and is representative of a larger section of the stream with respect to habitat, biological community, and expected response to human degradation. At each site, we evaluated ten characteristics representative of the quality of stream habitat and ten metrics to measure the biotic integrity from the individual, population, and community levels of ecological organization (Table 2).

The length of each study site is 20 times the mean width of the stream, or 100 meters, whichever is longer. Each site was divided into four equal-length quadrants within which each of the 20 different metrics was evaluated. The average of the quadrant scores at each site gave us the score for the site.

.

Figure 3. ***Kaneohe Watershed.***

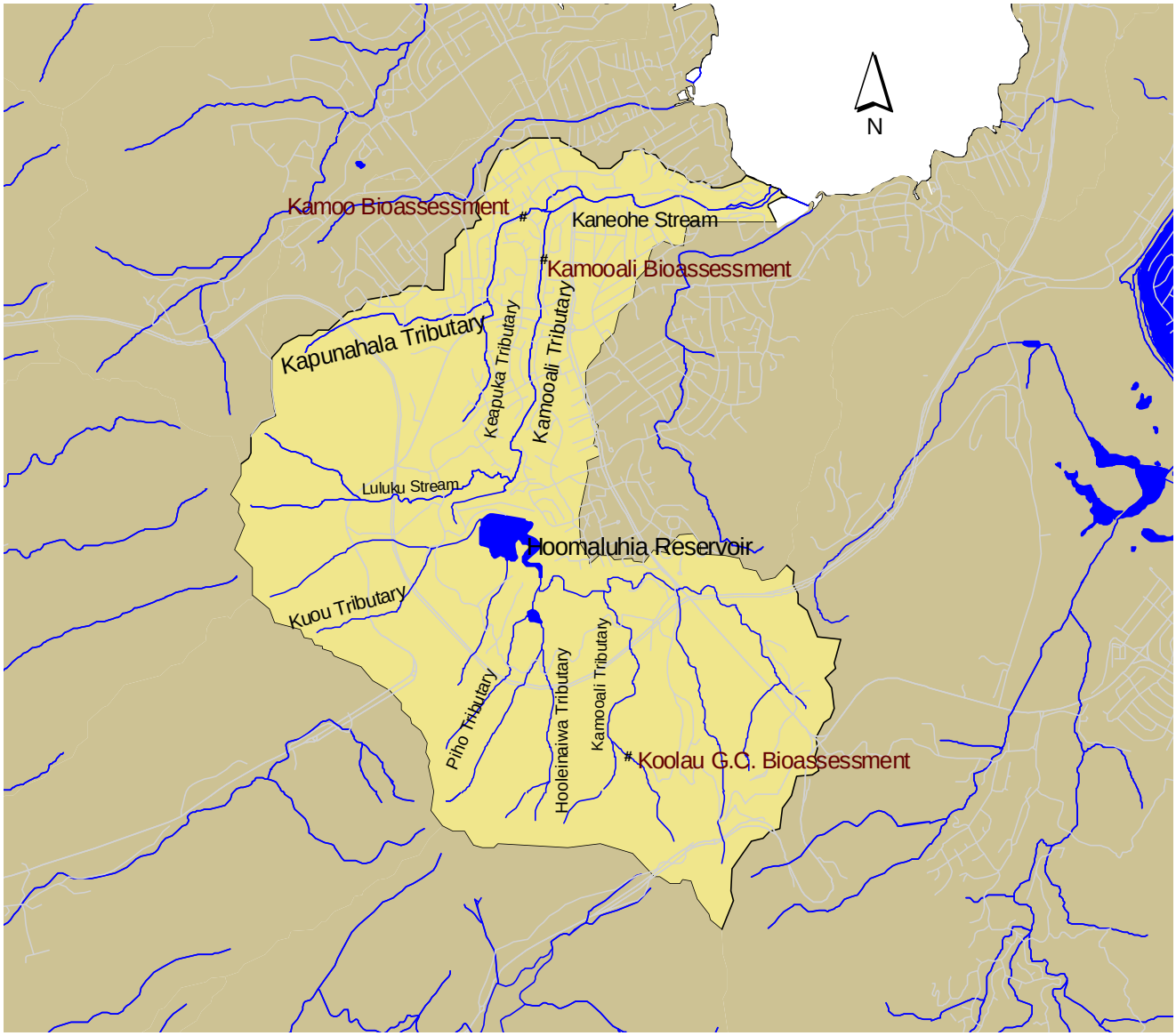
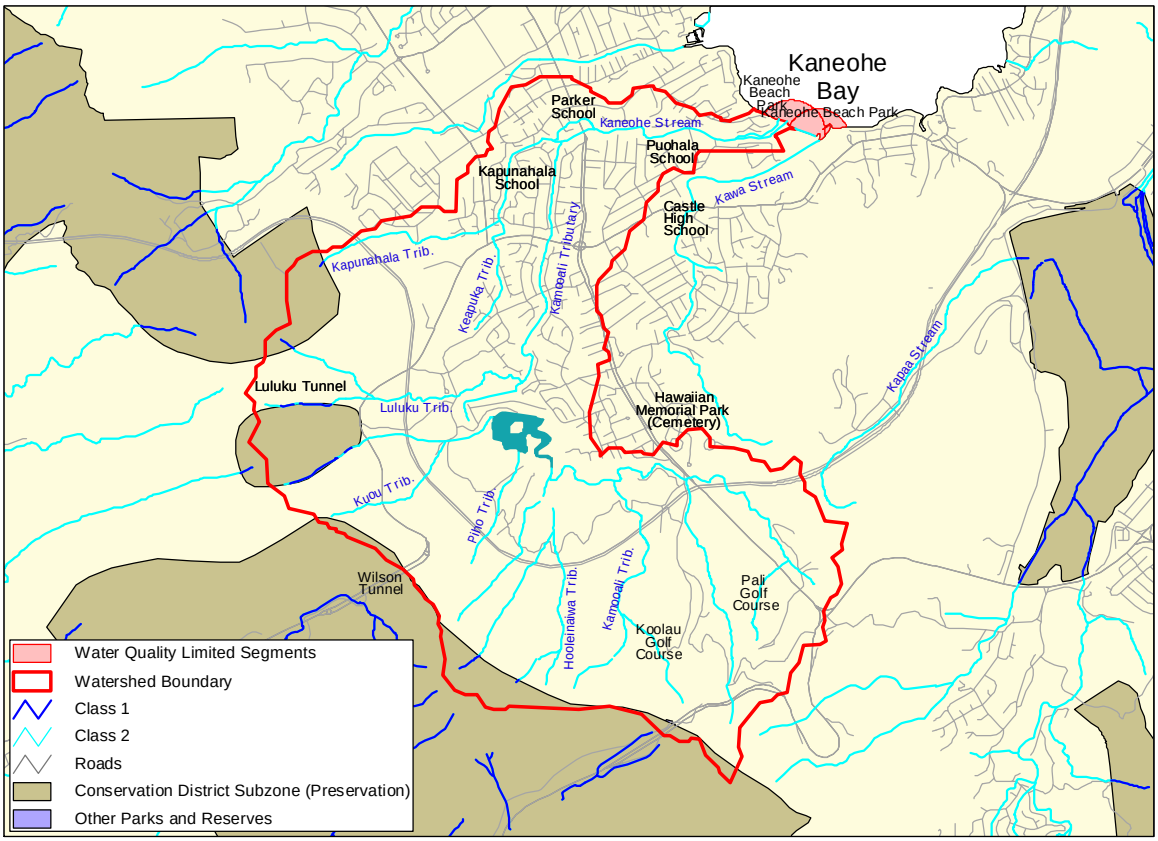


Figure 4. ***Classification of Kaneohe Stream.***



.

Table 2. Habitat characteristics and biological metrics against which assessment sites were measured.

Habitat	
Habitat availability	Heterogeneous habitat provides access for stream organisms to a variety of habitat types and hydrologic regimes.
Substrate embeddedness	Maximally exposed cobble and boulder substrate is abundant and limited quantities of sediment exist in the stream.
Fine and course particulate organic matter	Most organic matter is degraded, suspended, and transported out of the watershed.
Velocity-depth combinations	Heterogeneous patterns of stream flow velocity and depth provide a mix of hydrologic regimes that create a variety of physical microhabitats.
Channel flow status	The wetted stream width is nearly as large as the bankfull width, thus providing habitat for aquatic organisms.
Channel alteration	No alteration; maintains physical heterogeneity and natural habitat.
Bank stability	Both banks are intact and show no signs of erosion, maintaining natural habitat heterogeneity.
Riparian vegetative zone width	Intact and functional riparian zones have widths at least four times the mean width of the stream to retard landscape erosion and act as buffers against pollutants entering the water.
Riparian understory coverage	Intact understory plants prevent soil erosion and movement into the stream and maintain habitat for stream organisms.
Percent native riparian plant coverage	High percent of native plants indicate natural riparian conditions and high riparian quality. However, intact native riparian areas are uncommon in Hawaii and 12.5 percent coverage is the optimal expected coverage today.
Biological	
Number of native amphidromous macrofauna	Native species richness is high, but dependent upon slope gradient.
Percent contribution native taxa	Native aquatic species are numerically dominant (>75 percent) and except for the amphidromous alien prawn, *Macrobrachium lar*, alien species are entirely absent.
Percent native fish	At least 50 percent of the sample population of fish is expected to include *Lentipes concolor* or *Sicyopterus stimpsoni*, native species highly sensitive to environmental degradation.
Sensitive native fish density	High densities of sensitive native fish are found in robust fish populations.
Sensitive native fish size	Fifty percent of the sampled population of sensitive native fish should have a total length of at least 6.0 cm, as an indication of robust biotic integrity in terms of reproductive potential, trophic dynamics, species interactions, and environmental support.
Awaous guamensis size	*Awaous guamensis* is relatively common even in degraded streams. Fifty percent of the sampled fish population should have a total length of at least 8.0 cm, as an indication of robust biotic integrity in terms of reproductive potential, trophic dynamics, species interactions, and environmental support.
Total native fish density	Higher total native fish densities correlate with more natural ecological functioning, higher environmental quality, lower numbers of alien species, and reduced human influence.
Community weighted average	Native species dominate the community and alien species are either absent or in very low proportionate abundance.
Number of alien taxa	Streams either have no alien species present or low numbers of *M. lar*.
Percent tolerant alien fish	Even alien species that are highly tolerant of degraded conditions are in low proportionate abundance.

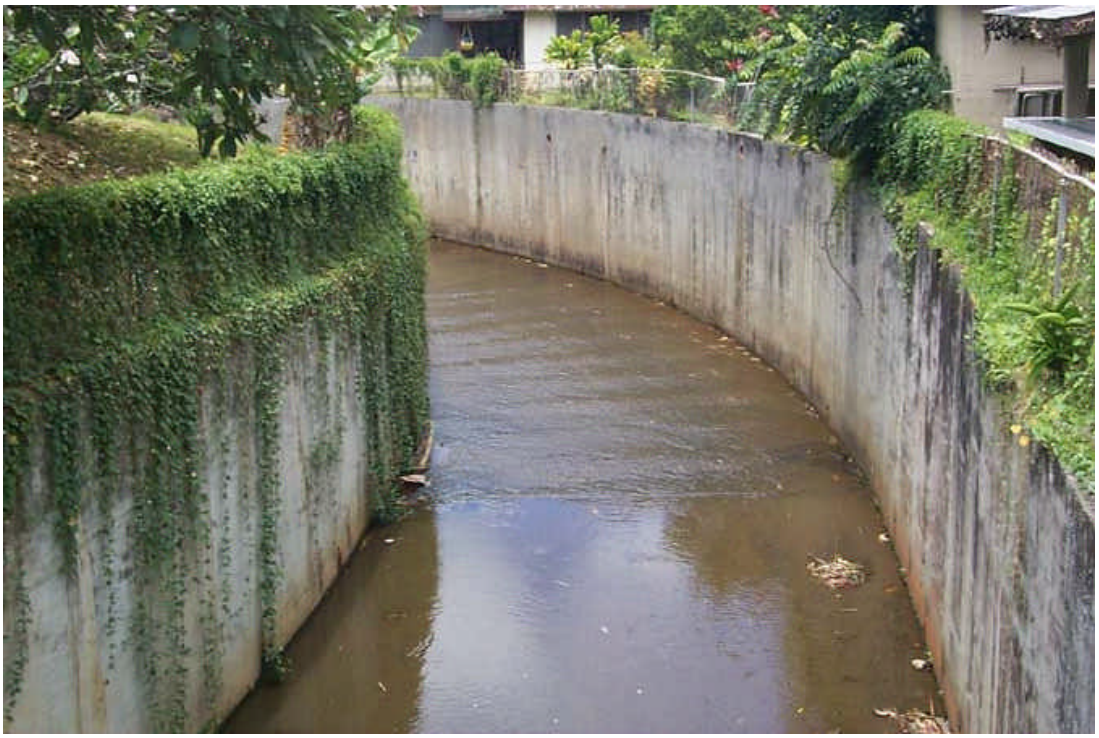
.

Site Descriptions

Kamoo Bridge

This section of the stream has been completely altered and functions more as a storm drain than a stream (Figure 5). The stream has been channelized and hardened as it flows through dense residential neighborhoods. Backyards abut a fence erected next to the channel, which has been designed to prevent access to the stream. No erosion is taking place, but neither are any natural processes, such as nutrient uptake in the riparian zone. The stream flows over the concrete bottom moderately fast, but is consistently shallow – good habitat for introduced poecellids and a few armored catfish, but little else. This tributary is not connected to the Hoomaluhia Reservoir; therefore many of the exotic fish that have been introduced in the reservoir are absent in this tributary. One small native fish, an *Awaous guamensis*, was found during the survey.

Figure 5. Kamoo Bridge site.



Kamooalii Tributary

This section of Kamooalii tributary is located below the Hoomaluhia Reservoir and is a straightened channel with a natural bedrock-lined bottom (Figure 6). Houses and a road are adjacent to this residential section of the stream. A thick growth of the aquatic plant, *Vallisneria* sp., has reduced the number of different habitat types. Introduced fishes, primarily aquarium releases from the reservoir, dominate the abundant fauna at this site – in fact, no native fish were observed during the survey. The City and County of Honolulu maintains this section of the stream with the goal of minimizing flooding of the adjacent houses. While conducting the survey at this station, an herbicide-spraying truck followed us down the middle of the stream, spraying herbicides along the bank and immediately next to the water.

.

Figure 6. ***Kamooalii Stream site.***

Koolau Golf Course

This section of the stream is the most natural when compared to the other sites surveyed, even though it is immediately next to the Koolau Golf Course (Figure 7). It has an intact riparian zone with a good understory and even a few native plants. This section of stream has a variety of habitats, although only two different flow regimes were present and the streambed exhibited evidence of sedimentation. Crayfish and guppies dominated the site, although small waterfalls and steps were home to an abundance of the native shrimp, *Atyoida bisulcata*. A large (26 cm) *Awaous guamensis* (`o`opu nakea), a native fish, was found in this section of stream.

Results

Ten habitat characteristics and ten biological metrics were evaluated at each station and then a score, expressed relative to the statewide reference condition, was assigned to the station.

.

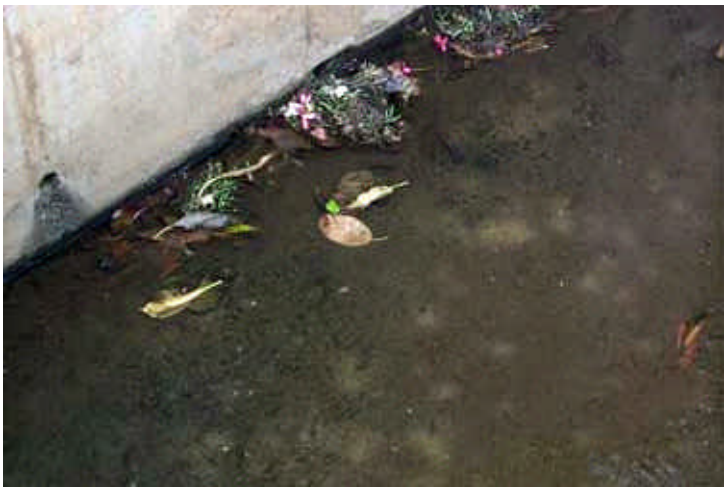
Figure 7. ***Koolau Golf Course site.***

Kamoo Bridge

Habitat:

Score 84.7
Percent of statewide reference 42%
Degree of attainment of aquatic life use.....Nonsupporting

Figure 8. ***Habitat at Kamoo Bridge site.***



The habitat score for the station at Kamoo Bridge, a completely hardened channel, is deceptively high, although still well below a supporting score (Figure 8). This site received perfect or near-perfect scores for embeddedness, sediment load, channel status, and bank stability – expected scores for a properly functioning storm drain. In contrast, the site received zero or near-zero scores for habitat availability, velocity-depths, channel alteration, riparian zone width, percent understory, and percent native riparian zone – poor scores for a properly functioning stream.

.

Biological metrics:

Score 10
Percent of statewide reference 20%
Evaluation of aquatic life .....Impaired

The small `o`opu nakea (*Awaous guamensis*) was a refreshing find in a section of the stream otherwise dominated by mollys (*Poecilia* sp. (salvatoris/mexicana group)). Even though the habitat in this section of the stream is unsuitable for amphidromous native fish, because of its life history, the sighting of the `o`opu is not that unusual. This tributary maintains a good connection to the ocean, so juvenile fish may enter the stream and make their way upstream until they reach suitable habitat. If the fish do not find suitable habitat, they are likely to die. If they do find suitable habitat, they will grow and reach a sufficient reproductive size.

The shallow, swiftly flowing water provides poor habitat for most fish. However, mollys, which are highly tolerant of degraded conditions, were abundant, and we also observed bristlenosed catfish (*Ancistrus* c.f. *temmincki*), convict cichlid (*Archocentrus nigrofasciatus*), and American crayfish (*Procambarus clarkii*). The introduced grass shrimp (*Neocaridina denticulata sinensis*) was abundant at this station. This tributary is not connected to the Hoomaluhia Reservoir; therefore it has quite a different assemblage of fishes as compared to the Kamooalii tributary station.

Kamooalii Tributary

Habitat:

Score 59.5
Percent of statewide reference 30%
Degree of attainment of aquatic life use.....Nonsupporting

Figure 9. Kamooalii Tributary site, looking downstream.

The natural streambed in this otherwise altered stream provides habitat for a variety of fishes, although none of them are native (Figure 9). This section of the stream was choked with *Vallisneria* sp., an introduced aquarium plant that traps sediment entering the stream from the eroding banks and further upstream. This sediment is likely released into the water column and carried downstream during storms when the *Vallisneria* sp. is torn up and carried downstream by swiftly flowing waters. The banks of this section of the stream are quite steep and kept bare and eroding by City and County of Honolulu personnel who regularly spray herbicides from a tanker truck driving down the center of the stream. Houses line one side of the stream and a major road is adjacent to the

.

other. Development of the surrounding residential area has eliminated the riparian zone, and the understory is absent on the bare banks.

Biological metrics:
Score 10
Percent of statewide reference 20%
Evaluation of aquatic life.....Impaired

The impressively diverse assemblage of fishes at the Kamooalii tributary station did nothing to raise the index of biological integrity score because none of the fishes were native. Bristlenosed catfish (*Ancistrus* c.f. *temmincki*) dominated the *Vallisneria* sp. habitat, but a wide variety of other species, including suckermouth catfish (*Hypostomus* c.f. *watwata*), molly (*Poecilia* sp. (salvatoris/mexicana group)), mosquito fish (*Gambusia affinis*), green swordtail (*Xiphophorus helleri*), convict cichlid (*Archocentrus nigrofasciatus*), Johanni cichlid (*Melanochromis johannii*), and black chin tilapia (*Sarotherodon melanotheron*) were present. A few individuals of the following species were also observed: Chinese softshell turtle (*Pelodiscus sinensis*), the amphidromous Tahitian prawn (*Macrobrachium lar*), and American crayfish (*Procambarus clarkii*). The introduced grass shrimp (*Neocaridina denticulata sinensis*) was abundant at this station.

Koolau Golf Course

Habitat:
Score 118.4
Percent of statewide reference 59%
Degree of attainment of aquatic life use.....Partially supporting

The Koolau Golf Course station is certainly the most natural of the three stations examined. The fairly steep stream channel is unaltered and the station has an intact riparian zone with a fair amount of understory and even some native trees (*Pandanas* sp.). However, the stream had a fair amount of sediment in it and not as much water as is expected, which eliminates habitat for native macrofauna and contributes to the *partially supporting* habitat score.

Biological metrics:
Score.....22
Percent of statewide reference 44%
Evaluation of aquatic life.....Moderately impaired

This station had relatively few fish; the aquatic macrofauna was dominated by two crustaceans, the native `opaekala`ole (*Atyoida bisulcata*) and the introduced American crayfish (*Procambarus clarkii*). The guppy (*Poecilia reticulata*) was the dominant fish, although in the lower quadrant of the station, we observed mosquito fish (*Gambusia affinis*) and one large (26 cm) `o`opu nakea (*Awaous guamensis*) (Figure 10). Unlike the downstream stations, the introduced grass shrimp (*Neocaridina denticulata sinensis*) was completely absent from this station

.

Figure 10. ***Large `o`opu nakea (Awaos guamensis*) found *at Koolau Golf Course site***

The large numbers of the mountain `opae and the presence of one large (of sufficient breeding size) `o`opu nakea brings the biotic integrity score of this station to *moderately impaired*. In an unimpaired Hawaiian stream not affected by humans, over 75% of the aquatic macrofauna are native (see Table 2). At 35% of native species, this station is nowhere near optimal.

Discussion

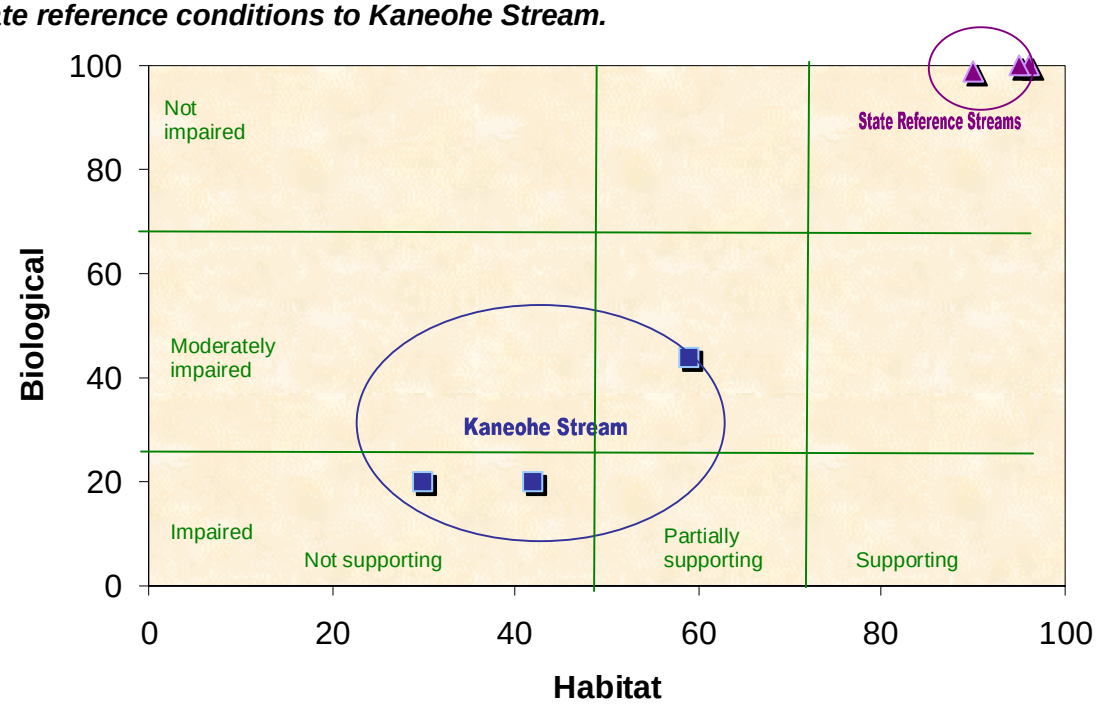
The Hawaii Stream Bioassessment Protocol is a standardized method used by the Hawaii Department of Health to assess stream habitat and biotic quality in the State of Hawaii. The scores can be used to prioritize streams for restoration and identify sources of degradation and affected ecological components. The scores from this bioassessment will help quantify Kaneohe Stream's pollution problem and will be valuable in preparing the Total Maximum Daily Load (TMDL) and setting water quality restoration goals for the stream.

The lower reaches of Kaneohe Stream are *non supporting* and the upper reach is p*artially supporting* for habitat quality, causing the biotic integrity of Kaneohe Stream to be *impaired to moderately impaired* (Figure 11). The habitat quality of Kaneohe Stream ranges from 30 percent at Kamooalii tributary to 59 percent at the Koolau Golf Course, with respect to the State reference condition. The biotic integrity of Kaneohe Stream is 20 percent at Kamoo Bridge and Kamooalii tributary and 44 percent at Koolau Golf Course.

Kaneohe Stream is a larger stream system than the other two windward O`ahu streams previously assessed as part of the TMDL process and as a result, does not have one defining characteristic responsible for its degree of impairment. The station at Koolau Golf Course is experiencing some bank erosion and sedimentation. The habitat scores at Kamooalii tributary station, which is downstream from the golf course station, reflect this increased sediment load in its low scores for habitat availability, embeddedness, sediment load, and velocity depths. This section of the stream also contributes to the sediment load from its bare and eroding banks and from discharge of the trapped sediments in the *Vallisneria* sp. aquarium plant in the stream bed.

.

Figure 11. ***Comparison of stream biotic integrity and supporting habitat quality of State reference conditions to Kaneohe Stream.***



In addition to the low biotic integrity scores resulting from the poor habitat characteristics at the stations on this tributary of Kaneohe Stream, the Hoomaluhia reservoir probably also plays a significant role. The presence of the artificial reservoir, filled with non-native predatory fish, makes it difficult for the native amphidromous fish and crustaceans to carry out their life cycle. It is difficult for the adults living upstream from the reservoir to successfully traverse the reservoir and continue downstream to spawn. Likewise, it is probably difficult for the juvenile animals to pass through the reservoir to the upper reaches of the stream where there is more suitable habitat. These non-native fish also readily escape from the reservoir and, as a result, dominate the biological communities of the lower reaches of the stream.

The Kamoo Bridge station has lost almost all of its naturalness and its ability to provide suitable habitat for native animals. The Kamoo Bridge station is unfortunately a typical example of an urban stream in Hawaii. The low habitat quality score and resulting low biotic integrity score demonstrates why past attempts to isolate the stream from the surrounding environment by hardening and straightening the channel have typically led to water quality problems and low bioassessment scores.

The Hawaii Stream Bioassessment Protocol is based upon the premise that habitat quality, biotic integrity, and water quality are inter-related. If the quality of the habitat in Kaneohe Stream is improved, water quality improvement and reappearance of a native stream ecosystem should follow. Enhancement of the riparian zones to provide “pretreatment” of the runoff from the watershed before it enters the stream and stabilization of stream banks should result in a reduction of sediments entering the stream, along with nutrients and other pollutants that accompany the sediments. This kind of restoration could be readily completed on the Kamooalii tributary and would make the stream less eutrophic. Eutrophication supports the herbivorous poecillids, including mollys and guppies that dominate Kaneohe Stream. A reduction in the trend toward eutrophication may reduce the large biomass of introduced fish species, and a reduction in the sediment load of the stream may make more habitat available to native amphidromous macrofauna.

.

Setting Environmental Management Goals Using Biological and Habitat Indicators

Water Quality Standards – Designated Uses, Narrative, and Numerical Criteria
Kaneohe Stream was placed on the 1998 CWA§303(d) List of Impaired Water bodies because it was found to not meet the narrative criterion expressed in HAR §11-54-04(a)(5), which prohibits "substances or conditions or combinations thereof in concentrations which produce undesirable aquatic life." Before 2001, no one regularly monitored for compliance with the numeric criteria, but a violation of the narrative criterion above likely means that the numeric standards were also violated; such as the geometric mean of total nitrogen not greater than 180 ug/L and the geometric mean for total phosphorus not greater than 30 ug/L (HAR §11-54-05.2(b)(1) – dry season values). These standards are set for all Hawaiian perennial streams in an effort to limit nutrient loading, which often leads to eutrophication.

A eutrophic stream is not likely to be capable of supporting the designated uses listed in the water quality standards. As set forth in HAR §11-54-03(b)(2), the uses to be protected in the Class 2 reaches of Kaneohe Stream encompass "all uses compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters." A eutrophic stream does not provide supporting habitat for native fish and is not conducive to recreation.

The following TMDL implementation goals are set for Kaneohe Stream:

> ***Class 2 segments***
> *Aquatic life uses shall be supported in Kaneohe Stream; the habitat characteristics shall be improved at least into the range of values indicating* partially supporting *habitat, and the biological community shall be brought at least into the range corresponding to* moderately impaired *as measured by the HSBI.*
>
> ***Class 1 segments***
> *Native breeding stock shall be protected in Kaneohe Stream; the habitat characteristics shall be in the range of values indicating* supporting *habitat, and the biological community shall be in the range corresponding to* unimpaired *as measured by the HSBI.*

These goals are consistent with the goals set for Waimanalo Stream (Smith, 1998) and Kawa Stream (Burr, 2001). The approach will require the habitat scores of Kamoo Bridge and Kamooalii tributary to improve from the range of 59.5 – 84.7 (30%-42% of reference) to the range of 100-150 (50%-75% of reference) and their biotic integrity scores to improve from 10 (20% of reference) to 15-35 (30%-70% of reference) (Table 3). The Koolau Golf Course station just meets these established goals with a habitat score of 118.4 (59% of reference) and a biotic integrity score of 22 (44% of reference).

Table 3. TMDL implementation goals for lower Kaneohe Stream (Class 2).

Attribute	*Current score range*	*Goal score range*
Habitat characteristics	*59.5 – 118.4*	*100-150*
Biological metrics	*10-22*	*15-35*

Although we do not know the current scores of the Class 1 segments of Kaneohe Stream because they were not surveyed at this time, the above goal requires the habitat scores to be in the range of 151- 200 (76-100% of reference) and the biotic integrity scores to be in the range of 36 – 50 (71%-100% of reference) (Table 4).

Table 4. TMDL implementation goals for the headwaters of Kaneohe Stream (Class 1).

Attribute	*Current score*	*Goal score range*
Habitat characteristics	*N/A*	*150-200*
Biological metrics		*35-50*

If the Class 2 sections of Kaneohe Stream are able to reach the partially supporting range for habitat characteristics and moderately impaired range for biotic integrity, they will more closely resemble the scores achieved by streams that maintain the highest quality of habitat and biota found on Oahu, although they will still remain considerably below the Hawaii reference streams. Once the target scores are met, then Kaneohe Stream should be capable of supporting the designated uses set forth in HAR §11-54-03(b)(2), despite it being a mostly urban waterbody.

.

Literature Cited

Burr, S. 2001. Kawa Stream Bioassessment. Department of Health, Honolulu, Hawaii. Pp. 16.

HIDOH. 1998. Hawaii's Water Quality-Limited Waters: The 1997 Assessment and 1998 CWA §303(d) List of Water Quality-Limited Segments. Pp. 34.

----------. 2001. Proposed Amendment to H.A.R. 11-54-03 and 05, Classification, Uses, and Specific Criteria for Inland Waters (Perennial Streams) –Rationale. Pp. 20.

Kido, M.H., G.C. Smith, and D.E. Heacock. 1999. The Hawaiian Stream Bioassessment Protocol (HSBP) Version 2.0: A Manual for Biological Monitoring and Assessment of Hawaiian Streams. Pp. 44.

Kinzie, R.A. 1990. Species Profiles: Life Histories and Environmental Requirements of Coastal Vertebrates and Invertebrates, Pacific Ocean Region. Part 3. Amphidromous Macrofauna of Hawaiian Island Streams. Biol. Rept. TR EL-89-10, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA/444/4-89-001. U.S. Environ. Prot. Agency, Washington, DC.

Smith, Gordon. March, 1998. Biological Assessment and Habitat Characterization of Waimanalo Stream: Establishing Environmental Goals and a TMDL for Watershed Management. Pp. 36.

.

APPENDIX A: Supplemental Biological Assessment for Kaneohe Stream: Luluku Gaging Station Site – February 2002

Conducted by Katina Henderson, Mike Kido, David Penn and Austin Seid

The Luluku Gaging Station site is located just upstream of USGS gaging station number 16270900 on the western edge of the Ho'omaluhia Botanical Garden. The site was characterized primarily by a riffle-run-cascade habitat with a small waterfall and plunge pool at the upstream edge of the site (Photographs 1 and 2). The Luluku Stream tributary flows into the Kamooalii tributary. Hoomaluhia Garden, urban residential and small agriculture dominated land-use at this site. On the left bank (facing downstream) near the waterfall and plunge pool was a small rooster farm while the botanical garden abutted the right bank with a small riparian strip of trees, shrubs and herbaceous plants. Endemic and indigenous plants were also present at this site such as tree ferns as were other Polynesian introductions such as taro. The bank substrate was dominated by hard claypan. The channel appeared to be natural or naturalized; however, the bank was eroding and deeply incised especially at the upstream end of the site (Photograph 3). The aquatic fauna was dominated by poecioliads and introduced shrimps. No native fish were found at this site.

Class 1 reaches of Kaneohe Stream were not accessible for assessment because the percentage of stream reach in the Kaneohe Watershed that is Class 1 is relatively low and those reaches that were explored were dry. Many of these stream segments are known for their intermittent nature. DOH added an additional site, the Luluku Gaging Station site, to represent the most minimally impacted, accessible waters in Kaneohe Stream. Though nearby residential communities impact this site to a limited degree, the conditions in this site were the most appropriate in such a highly developed area.

Habitat metrics:

Score	91.5
Percent of statewide reference	46%
Degree of attainment of aquatic life use	Nonsupporting

Biological metrics:

Score	10
Percent of statewide reference	18%
Evaluation of aquatic life	Impaired

This site was originally thought to be minimally impacted by development. However, the habitat scores proved to be *non-supporting,* resulting in an *impaired* status for the biological integrity of the stream. The score for habitat quality was only 46% of the statewide reference condition while the biotic integrity was 18% of the statewide reference condition. Surprisingly, this site had much lower scores for habitat and biotic integrity than those for the Koolau Golf Course site. Also, the scores for biological integrity were slightly lower than those in the lower reaches of Kaneohe Stream due to the abundance of multiple alien species. This site assessment supports the findings of degradation in previous biological assessments conducted for Kaneohe Stream, but shows that even some portion of the upper reaches of Kaneohe Stream are degraded to a point that the habitat is non-supporting and the biotic integrity is therefore impaired.

.

Photograph 1: Primary Habitat at Luluku Gaging Station Site

Photograph 2: Waterfall and Plunge Pool

Photograph 3: Eroded Banks

.